Claims

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of producing a GaAlInP compound semiconductor, the method comprising the steps of:

disposing a GaAs single crystal as a substrate in a metal organic chemical vapor deposition (MOCVD) reactor;

preparing Al, Ga, In vapors by thermally decomposing organometallic compounds of Al, Ga, and In;

preparing Zn vapors by thermally decomposing an organometallic Zn compound;

preparing P vapors by thermally decomposing phosphine gas;

simultaneously supplying the Al, Ga, In, P, Se, and Zn vapors to a region for epitaxial crystal growth on the substrate; and

epitaxially growing a GaAlInP crystal doped with Zn and Se on the substrate;

wherein flow rates of the Zn and Se vapors supplied to the region for epitaxial crystal growth are controlled to produce a heavily doped GaAlInP compound semiconductor with Zn serving as a p-type dopant at an atomic ratio of Zn:Se greater than two in the GaAlInP crystal.

2. The method of claim 1 and further comprising:

providing a gas switching manifold in the metal organic chemical vapor deposition (MOCVD) reactor; and

preparing the Al, Ga, In vapors in the gas switching manifold.

3. The method of claim 1 and further comprising:

providing a gas switching manifold in the metal organic chemical vapor deposition (MOCVD) reactor; and

preparing the Zn vapors in the gas switching manifold.

4. The method of claim 1 and further comprising:

providing a gas switching manifold in the metal organic chemical vapor deposition (MOCVD) reactor; and

preparing the P vapors in the gas switching manifold.

5. The method of claim 1 and further comprising:

providing a reaction chamber in the metal organic chemical vapor deposition (MOCVD) reactor;

positioning a susceptor within the reaction chamber;

positioning the substrate on the susceptor; and

heating the substrate.

6. The method of claim 5 and further comprising:

heating the substrate to a temperature of between approximately 500°C and 650°C.

7. The method of claim 1 wherein the hydride sources are selected from the group consisting of AsH_3, PH_3, H_2Se, and Si_2H_6.

8. The method of claim 1 wherein the organometallic compounds are organometallic sources selected from the group consisting of trimethylaluminum (TMAl), triethylgallium (TEGa), trimethylindium (TMIn), and dimethylzinc (DMZn).

9. The method of claim 1 and further comprising:

epitaxially growing a codoped GaAlInP layer by exposing the heated substrate to Al, Ga, In, P, Zn, and Se vapors.

10. A method of producing a GaAlInP compound semiconductor, the method comprising the steps of:

disposing a GaAs single crystal as a substrate in a metal organic vapor deposition reactor;

preparing Al, Ga, In vapors by thermally decomposing organometallic compounds of Al, Ga, and In,

preparing P vapors by thermally decomposing phosphine gas;

preparing group II element vapors by thermally decomposing an organometallic group IIA or IIB compound;

preparing group VIB vapors by thermally decomposing a gaseous compound of group VIB;

simultaneously supplying the Al, Ga, In, P, group II, and group VIB vapors to a region for epitaxial crystal growth on the substrate; and

epitaxially growing a GaAlInP crystal doped with group IIA or IIB and group VIB elements on said substrate;

wherein the group IIA or IIB and group VIB vapors supplied to the region for epitaxial crystal growth produce a codoped GaAlInP compound semiconductor with a group IIA or IIB

element serving as a p-type dopant having low group II atomic diffusion at an atomic ratio of II:VI greater than approximately two (2) in the GaAlInP crystal.

11. The method of claim 10 and further comprising:

providing a gas switching manifold in the metal organic chemical vapor deposition (MOCVD) reactor; and

preparing the Al, Ga, In vapors in the gas switching manifold.

12. The method of claim 10 and further comprising:

providing a gas switching manifold in the metal organic chemical vapor deposition (MOCVD) reactor; and

preparing the group II element vapors in the gas switching manifold.

13. The method of claim 10 and further comprising:

providing a gas switching manifold in the metal organic chemical vapor deposition (MOCVD) reactor; and

preparing the P vapors in the gas switching manifold.

14. The method of claim 10 and further comprising:

providing a gas switching manifold in the metal organic chemical vapor deposition (MOCVD) reactor; and

preparing the group VIB vapors in the gas switching manifold.

15. The method of claim 10 and further comprising:

providing a reaction chamber in the metal organic chemical vapor deposition (MOCVD) reactor;

positioning a susceptor within the reaction chamber;

positioning the substrate on the susceptor; and

heating the substrate.

16. The method of claim 15 and further comprising:

heating the substrate to a temperature of between approximately 500°C and 650°C.

17. The method of claim 10 wherein the hydride sources are selected from the group consisting of AsH_3, PH_3, H_2Se, and Si_2H_6.

18. The method of claim 10 wherein the organometallic compounds are organometallic sources selected from the group consisting of trimethylaluminum (TMAl), triethylgallium (TEGa), trimethylindium (TMIn), and dimethylzinc (DMZn).

19. The method of claim 12 and further comprising:

spitaxially growing a codoped GaAlInP layer by exposing the heated substrate to Al, Ga, In, P, group IIA or group IIB, and group VIB vapors.

20. A GaAlInP compound semiconductor, the GaAlInP compound semiconductor comprising:

a substrate, the substrate being a GaAs single crystal positioned within a metal organic chemical vapor deposition (MOCVD) reactor;

Al, Ga, In vapors from thermally decomposed from organometallic compounds of Al, Ga, and In;

P vapors thermally decomposed phosphine gas;

Group II vapors thermally decomposed from an organometallic group IIA or IIB compound; and

group VIB vapors thermally decomposed from a gaseous compound of group VIB, the Al, Ga, In, P, group II, and group VIB vapors being applied to a region for epitaxial crystal growth on the substrate;

wherein the group IIA or IIB and group VIB produce a codoped GaAlInP compound semiconductor with a group IIA or IIB element serving as a p-type dopant having low group II atomic diffusion at an atomic ratio of II:VI greater than approximately two (2) in the GaAlInP crystal.

21. The GaAlInP compound semiconductor of claim 20 wherein the metal organic chemical vapor deposition (MOCVD) reactor has a gas switching manifold and the Al, Ga, In vapors are prepared in the gas switching manifold.

22. The GaAlInP compound semiconductor of claim 20 wherein the metal organic chemical vapor deposition (MOCVD) reactor has a gas switching manifold and the group II vapors are prepared in the gas switching manifold.

23. The GaAlInP compound semiconductor of claim 20 wherein the metal organic chemical vapor deposition (MOCVD) reactor has a gas switching manifold and the P vapors being prepared in the gas switching manifold.

24. The GaAlInP compound semiconductor of claim 20 wherein the metal organic chemical vapor deposition (MOCVD) reactor has a gas switching manifold and the group VIB vapors being prepared in the gas switching manifold.

25. The GaAlInP compound semiconductor of claim 20 wherein the metal organic chemical vapor deposition (MOCVD) reactor has a reaction chamber and a susceptor positioned within the reaction chamber with the substrate being positioned on the susceptor.

26. The GaAlInP compound semiconductor of claim 25 wherein the substrate is heated to a temperature of between approximately 500°C and 650°C.

27. The GaAlInP compound semiconductor of claim 20 wherein the sources are selected from the group consisting of AsH_3, PH_3, H_2Se, and Si_2H_6.

28. The GaAlInP compound semiconductor of claim 20 wherein the organometallic compounds are organometallic sources selected from the group consisting of trimethylaluminum (TMA1), triethylgallium (TEGa), trimethylindium (TMIn), and an organometallic compound of group IIA or group IIB.